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The results are presented of a detailed commonwealth-wide emission inventory of particulate, sulfur oxide, hydrocarbon, carbon monoxide, and nitrogen oxide sources of atmospheric pollution. Using questionnaires containing raw data, 342 sources were selected for point source processing based on a minimum of 10 tons per year emissions. These sources were coded in detail and processed as point source data. Additional data on commonwealth-wide fuel usage, vehicular traffic, waste disposal, solvent evaporation, vessel traffic, aircraft activity, and sugar cane field burning were collected and processed as area sources. The report also presents a description of the task, description of the study area, definition of the grid coordinate system used, and details of the methodology employed.

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October 18, 1971

DETAILED EMISSION INVENTORY FOR THE COMMONWEALTH OF PUERTO RICO

FINAL REPORT

for

Environmental Protection Agency
Office of Air Programs
Regional Office
26 Federal Plaza
Room 832
New York, New York 10007

under

Contract Number 68-02-0042

By

Mr. Billy Don Weaver, Director
Environmental Management Program

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Section 1.0

INTRODUCTION

This report is a summary of the work performed by GEOMET, Incorporated under Task 2 of Contract Number 68-02-0042 for the Environmental Protection Agency (EPA) in conjunction with the Environmental Quality Board (Junta De Calidad Ambiental) of the Commonwealth of Puerto Rico.

The results of this work provide a detailed commonwealth-wide emissions inventory of particulate, sulfur oxide, hydrocarbon, carbon monoxide, and nitrogen oxide sources of atmospheric pollution.

The emissions inventory resulting from this task is considered representative of calendar year 1970. The data represent realistic estimates of emissions but should not be interpreted as absolute values. The basis for the raw data was questionnaries on individual sources with information on the questionnaires being written either by Puerto Rico air pollution agency personnel, based on personal interviews, or by the involved firms replying to a written solicitation for data.

The Puerto Rico Environmental Quality Board (EQB) has a file of over 2000 sources; questionnaires are filled out in varying degrees of completeness on each source. An additional 110 sources were solicited for data by GEOMET.

Using these data, GEOMET selected 342 sources for point source processing based on a minimum of 10 tons per year emissions. These sources were coded in detail and processed as point source data. Additional data on commonwealth-wide fuel usage, vehicular traffic, waste

disposal, solvent evaporation, vessel traffic, aircraft activity, and sugar cane field burning were collected and processed as area sources.

Detailed computer processing results are provided separately from this report. A summary of these data is provided in Section 2.0 of this report and in the detailed summary table shown in Appendix A. Section 3.0 provides a description of the task performed by GEOMET. The description of the study area and a definition of the grid coordinate system used are provided in Section 4.0. Details of the methodology employed by GEOMET in accomplishing this task are given in Section 5.0. References used in this work are shown in Section 6.0. Appendix B presents a listing of the political jurisdictions of Puerto Rico, and Appendix C presents a point source data coding form.

This report reflects comments and suggestions made by the EPA and the EQB as a result of an earlier (August 16, 1971) draft report on the detailed emission inventory for Puerto Rico.

Section 2.0

SUMMARY

A detailed summary table, similar in format to the requirements of Appendix D of the August 14, 1971 Federal Register, of emissions in Puerto Rico is shown in Appendix A. This section briefly summarizes the emissions and provides a pictorial view of the percentage distribution of them by use of pie charts.

The estimated annual emissions for Puerto Rico determined from the commonwealth-wide emissions inventory are:

Particulates	95,195 tons
Sulfur Oxides	144,533 tons
Carbon Monoxide	600,876 tons
Hydrocarbons	116,235 tons
Nitrogen Oxides	117,762 tons

Table 1 provides a summary of these pollutants by source category. This table is similar in format to the Appendix G requirements of the August 14, 1971 Federal Register.

Figure 1 shows the percentages, by source category, of emissions represented by the data in Table 1.

The following paragraphs present a brief discussion of the emissions.

Particulates: Point sources were responsible for the highest percentage of particulate emissions (90%) with area sources contributing the remaining 10%. Industrial process sources made the largest contribution.

Table 1. Emissions Inventory Summary, Tons/Year *

Source Category	Pollutant				
	Particulates	SO_2	CO	HC	NO_x
I. Fuel Combustion - Stationary Sources					
A. Area Sources	1,428	15,439	335	309	5,339
B. Point Sources	5,899	117,459	75	2,144	41,064
C. Total	7,327	132,898	410	2,453	46,403
II. Process Losses					
A. Area Sources	0	0	0	0	0
B. Point Sources	79,387	2,594	60,097	12,229	6,599
C. Total	79,387	2,594	60,097	12,229	6,599
III. Solid Waste Disposal					
A. Area Sources	5,457	341	28,993	10,233	2,047
B. Point Sources	0	0	0	0	0
C. Total	5,457	341	28,993	10,233	2,047
IV. Transportation (Area Sources Only)	3,016	8,700	511,322	88,533	62,712
V. Miscellaneous (Area Sources Only)	8	0	54	2,787	1
VI. Grand Totals					
A. Area Sources	9,909	24,480	540,704	101,862	70,099
B. Point Sources	85,286	120,053	60,172	14,373	47,663
C. Total	95,195	144,533	600,876	116,235	117,762

* Puerto Rico Air Quality Control Region (244)
Data Representative of Calendar Year 1970

Sulfur Oxides: Individual point sources contributed 83% of the sulfur oxide emissions with area sources contributing the remaining 17%. Fuel combustion sources contributed 92% of the sulfur oxide emissions. The fuel sources (92%) were composed of individual commercial-institutional-industrial sources (40%) and steam-electric power plants (52%). The power plants are thus the largest single group of sulfur oxide emitters. Transportation sources contributed 6% with process sources contributing less than 2%.

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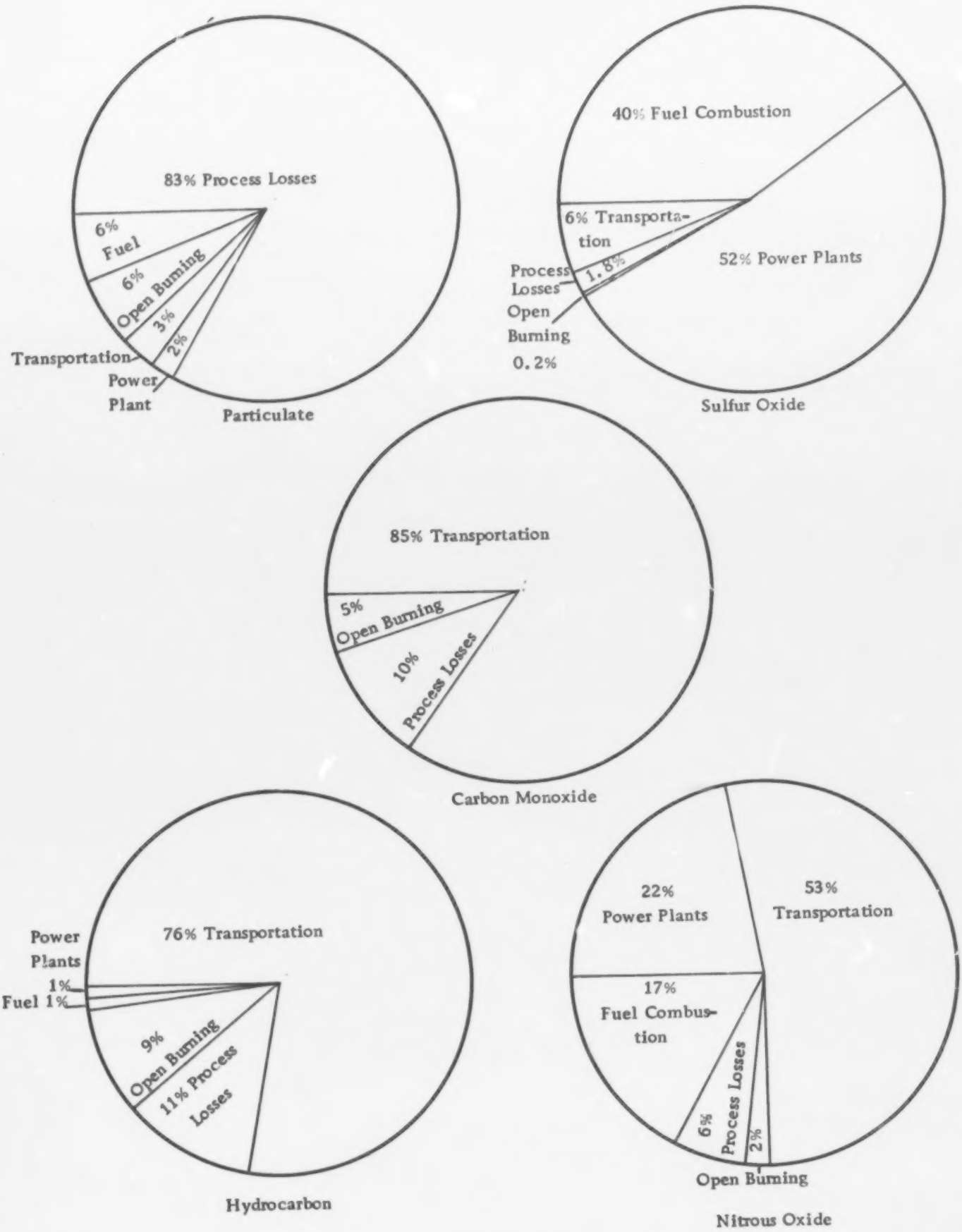

Figure 1. Emissions by Source Category

Carbon Monoxide: Area sources contributed 90% of the carbon monoxide emissions; transportation sources were the largest contributors and accounted for 85% of the commonwealth-wide total. The next largest area source contribution was open burning with 5% of the total. Point sources contributed 10% of the total, with industrial process sources providing almost all of this contribution (9.7%).

Hydrocarbons: These emissions consisted of 88% from area sources and 12% from point sources. Transportation sources accounted for 76% of the total, open burning 9%, and process sources (primarily refineries) 11%; the remaining 4% came from fuel combustion (2%) and miscellaneous sources (2%).

Nitrous Oxides: These emissions came from area sources (60%) and point sources (40%). Transportation sources accounted for 53% of the total nitrous oxide emissions, and point source fuel combustion accounted for 39% of the total; process losses (6%) and solid waste disposal (2%) accounted for the bulk of the remainder of these emissions.

Table 2 is provided to show the level of pollutant emissions for each municipality. These emissions are totals, including both point and area sources.

Table 2. Total Emissions for Each Municipality for 1970

Municipalities		Pollutant - Tons/Year				
Political Jurisdiction Number	Name	Particulates	SO_2	CO	HC	NO_x
1	Aguas Buenas	1,779	60	1,913	414	314
2	Barranquitas	55	56	2,181	466	367
3	Bayamón	4,205	1,184	45,628	7,874	5,040
4	Carolina	861	2,144	33,040	6,042	3,416
5	Cataño	1,180	26,288	8,550	1,900	9,783
6	Cidra	156	204	1,947	449	336
7	Comerio	68	264	1,788	398	322
8	Corozal	571	109	2,937	628	477
9	Dorado	813	4,101	2,072	473	952
10	Guaynabo	7,818	3,401	12,290	2,260	2,476
11	Naranjito	55	22	2,437	518	392
12	Rio Piedras*	-	-	-	-	-
13	San Juan	3,142	42,267	161,551	29,900	31,059
14	Toa Alta	52	57	2,272	479	370
15	Toa Baja	612	428	3,992	839	749
16	Trujillo Alto	4,594	718	4,843	1,017	884
17	Adjuntas	57	65	2,334	491	381
18	Aibonito	60	36	2,290	491	373
19	Arroyo	372	94	1,378	289	223
20	Coamo	76	73	3,192	614	334
21	Guanica	2,938	2,489	12,330	1,651	1,360
22	Guayama	368	3,139	5,360	1,314	3,810
23	Guayanilla	2,773	14,679	3,885	1,223	9,639
24	Jayuya	42	48	1,405	307	214
25	Juana Diaz	105	135	3,290	647	344
26	Orocovis	51	17	1,540	349	245
27	Patillas	1,458	11	1,429	323	206
28	Peñuelas	431	15,324	1,701	606	5,320
29	Ponce	17,712	9,949	39,973	11,944	7,062
30	Salinas	1,340	422	8,157	1,146	821
31	Santa Isabel	304	67	2,630	444	313
32	Villalba	44	14	1,808	389	284
33	Yauco	94	99	5,642	1,027	597
34	Aguada	4,992	1,258	8,341	1,149	910
35	Aguadilla	174	347	7,901	1,467	1,134
36	Añasco	55	64	2,265	481	383
37	Cabo Rajo	3,826	169	4,973	1,019	864
38	Hormigueros	1,739	522	5,687	771	584
39	Isabela	100	183	3,883	828	652
40	Lajas	59	104	2,817	581	508

* Emissions for Rio Piedras are Included in San Juan.

(Continued)

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Table 2. Total Emissions for Each Municipality for 1970 (Concluded)

Municipalities		Pollutant - Tons/Year				
Political Jurisdiction Number	Name	Particulates	SO_2	CO	HC	NO_x
41	Las Marias	26	6	919	203	142
42	Maricao	17	4	550	123	81
43	Mayaguez	3,906	3,181	26,558	4,571	3,718
44	Moca	64	90	2,238	484	354
45	Rincón	33	54	1,176	252	223
46	Sabana Grande	53	32	2,524	528	440
47	San German	1,683	112	4,562	955	829
48	San Sebastian	1,327	1,390	9,573	1,472	1,197
49	Arecibo	2,489	1,701	17,739	3,617	2,154
50	Barceloneta	804	1,863	5,855	949	942
51	Camuy	1,039	458	6,072	910	672
52	Ciales	488	99	1,569	340	269
53	Hatillo	72	184	1,900	422	331
54	Lares	63	22	2,751	580	416
55	Manati	4,843	459	9,959	1,540	1,169
56	Morovis	53	54	1,766	391	284
57	Quebradillas	1,019	163	2,011	418	353
58	Utuado	576	117	3,589	805	568
59	Vega Alta	71	150	2,852	602	492
60	Vega Baja	2,110	540	5,118	1,058	982
61	Caguas	4,500	448	19,763	3,491	2,254
62	Cayey	120	187	5,517	1,040	585
63	Ceiba	64	161	1,515	322	265
64	Fajardo	1,530	288	6,779	1,069	643
65	Gurabo	62	151	2,276	488	397
66	Humacao	696	229	5,629	1,034	686
67	Juncos	524	261	5,702	911	551
68	Las Piedras	64	230	2,459	462	338
69	Loiza	801	354	4,460	937	794
70	Luquillo	35	28	1,508	320	248
71	Maunabo	26	6	857	191	127
72	Naguabo	53	21	2,268	485	357
73	Rio Grande	77	227	3,213	605	367
74	San Lorenzo	86	117	2,699	594	447
75	Yabucoa	702	539	5,298	868	642

Section 3.0

TASK DESCRIPTION

The purpose of the task performed by GEOMET in conjunction with the Environmental Quality Board of the Commonwealth of Puerto Rico was to produce a detailed emission inventory of Puerto Rico for the following pollutants: particulates, sulfur oxides, carbon monoxide, hydrocarbons, and nitrous oxides.

A meeting was held on May 7, 1971 among the EQB, EPA, and GEOMET to detail responsibilities for task completion. The following is a summary of the work agreed upon at that meeting.

The Department of Health of the Commonwealth of Puerto Rico had recently completed the collection of emission inventory information for approximately 2000 sources throughout the Commonwealth. As described by the agency, it appeared that the available information could serve as an excellent data base for the purposes of developing an implementation plan. However, four distinct work areas existed before the data could be finalized and tabulated into a usable format:

1. Data must be collected for an additional 100 sources, including all Federal facilities. In addition, some of the 2000 source forms are incomplete and some contacts may be required to collect the remaining data.

2. The available data are representative of 1969 and in most cases will be applicable for 1970. Changes in some process sources have taken place, therefore, updating of specific sources will be required.

3. Revisions of the area source data are required to update known changes.

4. The data, both for point and area sources, should be recorded for computer processing and processed at the EPA facility with results given to the EQB and the EPA.

Section 4.0

STUDY AREA

4.1 DESCRIPTION OF STUDY AREA

The Commonwealth of Puerto Rico consists of 77 municipalities and covers an area of 3,423 square miles; the population of Puerto Rico as of January 1970 was 2,801,400. The main island has 75 municipalities with the Islands of Culebras and Vieques being the remaining two. Figure 2 shows the outline of the island and the municipalities as of the end of 1970.

Temperatures within Puerto Rico maintain an average of 75^{o}F in the winter and 80^{o}F in the summer. The trade winds prevail on the island from the east, northeast, and southeast.

Puerto Rico comprises one Air Quality Control Region (AQCR). The 77 municipalities are in AQCR 244. Appendix B lists the municipalities with assigned political jurisdiction numbers. The numbering system is grouped alphabetically into Health Regions (Puerto Rico system).

4.2 GRID COORDINATE SYSTEM

A grid coordinate system based on the Universal Transverse Mercator Projection (UTM) for Puerto Rico was selected at the initial meeting. Maps, utilizing tick marks with this sytem, were obtained from the Department of Public Works in San Juan. These maps, 1:20,000 scale, were mapped, edited, and published by the Geological Survey complying with National Map accuracy standards. The reference point is the same for all areas of Puerto Rico, and all coordinates are positive. The grid systems and coordinates are illustrated in Figure 2.

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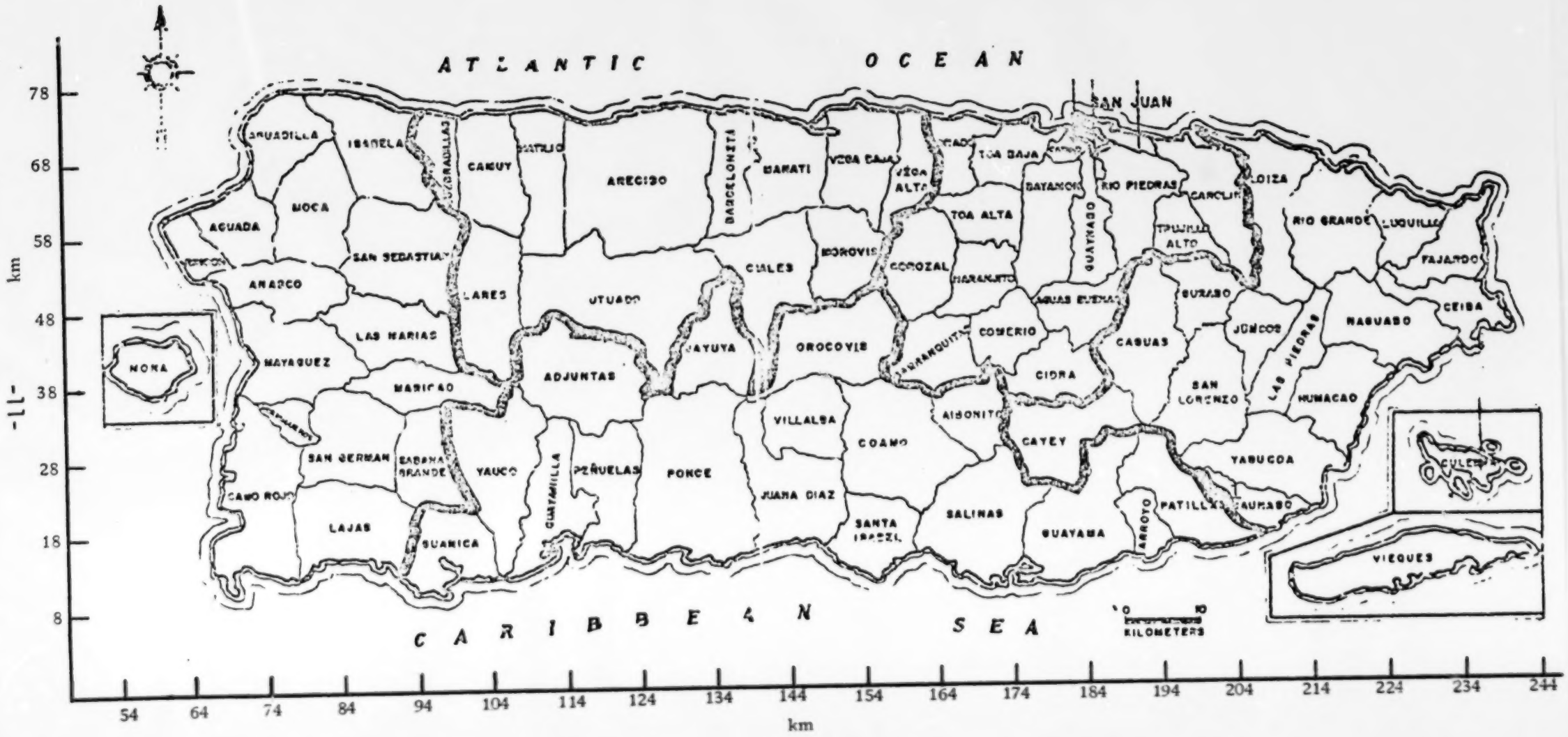

Figure 2. Outline of Puerto Rico Study Area

Section 5.0

METHODOLOGY

5.1 GENERAL APPROACH

The following is a general description of the approach used in this task to obtain the required emissions inventory. Sections 5.2 and 5.3 provide more details on the specific methodology for point and area sources, respectively.

The Air Pollution Control Program of the Puerto Rico Department of Health had already collected, through personal interviews, data on over 2000 sources in Puerto Rico. These data are on questionnaires and represent all types of commercial, institutional, and industrial sources. An additional 110 sources were contacted by letter and asked to supply data by filling out questionnaires. These data were separated into two groups. One group was sources having more than 10 tons of emissions per year or representing specified industries named in Appendix C of the August 14, 1971 Federal Register with no lower cut-off point. These were the sources selected for coding for the point source inventory. Emission calculations were made for all process sources using emission factors in the EPA publication, Compilation of Air Pollutant Emission Factors (McGraw and Duprey 1970), or specified factors supplied by the EQB. Combustion source calculations were made by the EPA computer program based on type and quantity of fuel and the sulfur content of the fuel.

The data for 342 point sources (not all individual firms) were coded and processed by the EPA point and area source computer program at the Research Triangle Facility.

The second group of point source forms representing minor sources and sources with incomplete data was coded with whatever available information appeared on the forms. No recontacting of these sources was attempted. These data were card punched in the point source format and listed by computer to provide a record of the available information on these approximately 1700 minor sources. These cards were not processed on the EPA program since fuel consumption and process weight information was incomplete.

Material processed or consumed on the island which could not be attributed to specific point sources was included in area sources. These data include fuel usage for commercial, institutional, and industrial sources (residential heating is nonexistent); open burning of waste material; solvent evaporation from dry cleaning operations; diesel fuel usage by seagoing vessels; diesel fuel used by vehicles; LPG (propane and butane) use; gasoline usage by vehicles; sugar cane field burning; and aircraft activity at airports. These consumables were allocated to each municipality (procedures described in Section 5.3) and coded, keypunched, and processed on the EPA area source program. A second area source compilation was made for the greater San Juan area. The eight municipalities included in this second grouping were: San Juan, Carolina, Trijillo Alto, Guaynabo, Bayamon, Toa Alta, Toa Baja, and Catano. Originally, Rio Piedras was coded as a separate municipality, it has, in fact, been merged into the San Juan municipality. The numbering system shown in Appendix B was not changed as it would confuse earlier work. A grid system consisting of 62 grid squares was developed for this area.

The system consisted of 43 grid squares 2 kilometers on a side (4 sq. kilometers) and 19 grid squares 4 kilometers on a side (16 sq. kilometers). This system is illustrated in Figure 3. Data for this grid system were developed to further delineate the emission picture in the San Juan area but are not additional emissions over those shown for the municipality by municipality results.

A third area source compilation was made for the Ponce area. A grid system comprised of 24 grid squares was set up for Ponce and is illustrated in Figure 4.

The results of the point source and area source emission invetory calculations are available separate from this report at the EPA-OAP Surveillance section, the EPA Region II office, and at the EQB office in Puerto Rico. A detailed summary of these results is provided in Table A-1 of Appendix A of this report. Sections 5.2 and 5.3 present more details of data sources and procedures for point and area sources.

5.2 POINT SOURCES

5.2.1 Obtaining of Data

The basic source of data on point sources was the questionnaires on file at the APCP (now at the EQB) or those additional ones acquired by the GEOMET mailing. Recontacts were made to sources for which file data were insufficient, but needed.

All power plants come under one agency, the Puerto Rico "Water Resources Authority." This agency provided updated data on all power plants.

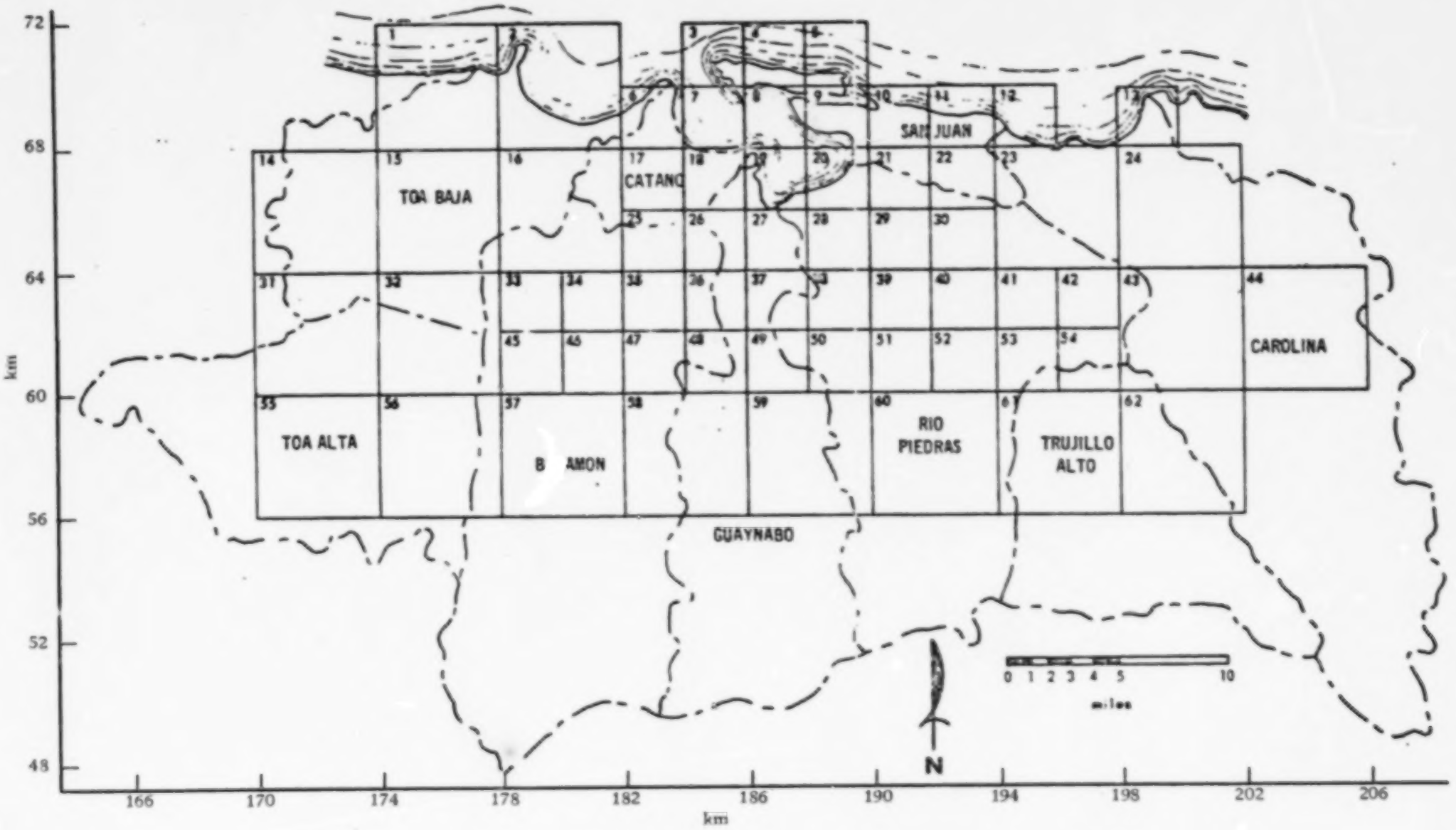

Figure 3. Grid Coordinate System for San Juan Area Grid

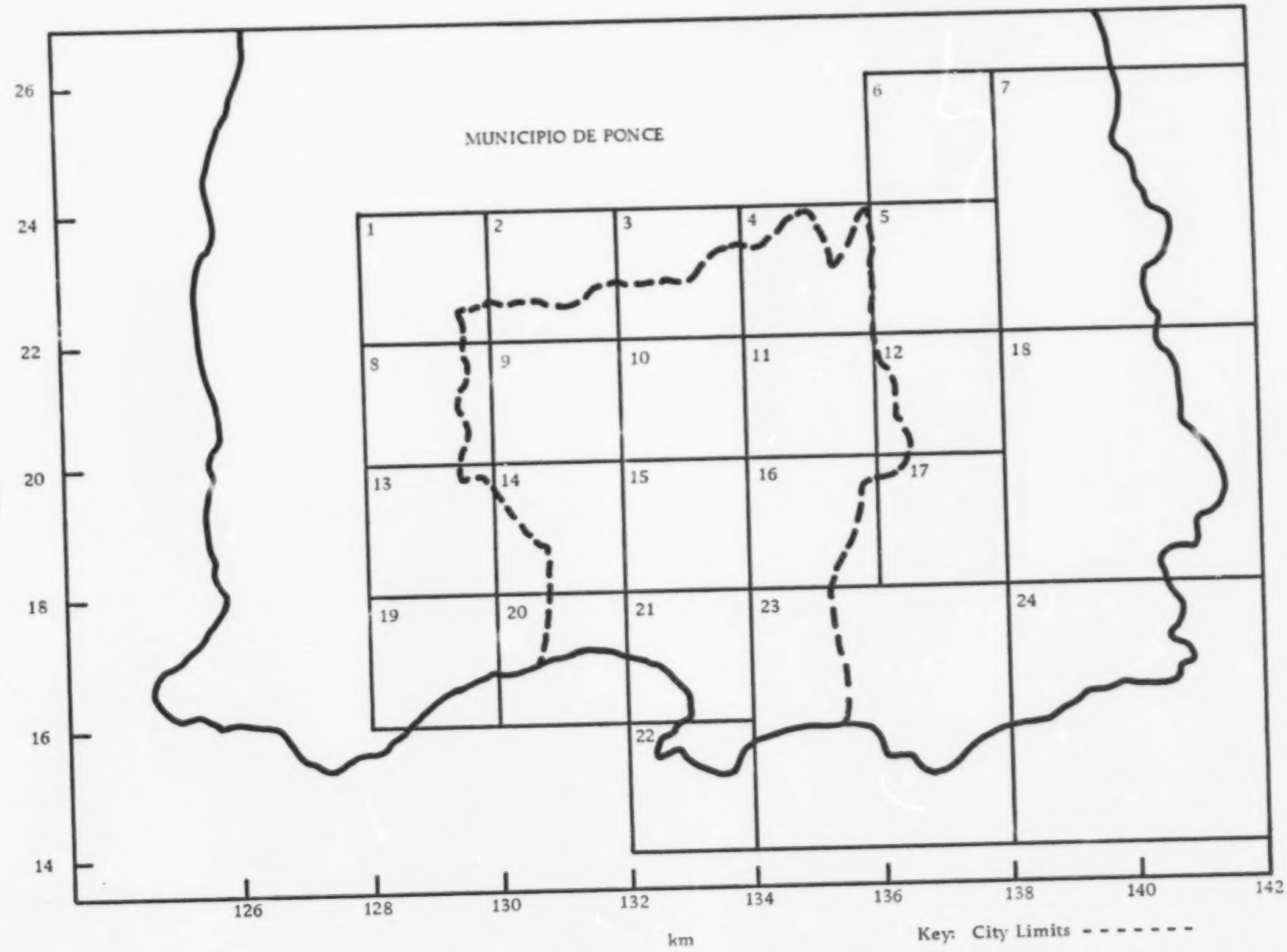

Figure 4. Grid System for Ponce Area

5.2.2 Calculations

Each point source selected for inclusion in the point source emission inventory was first examined as to the manner in which emissions occurred (process or combustion). A given firm might have several sources and might have both process and combustion sources. Each emission source at a given firm was coded as a separate source.

Process source calculations were made based on the type of process, the process weight rate, and the EPA emissions factor book (McGraw and Duprey 1970). Hand calculations were made on the basis of uncontrolled emissions; if a control device was available, it was coded and the computer program calculated the controlled emissions.

Combustion source calculations were made by the computer program based upon the type and quantity of fuel burned and the sulfur content of the fuel.

One source type was coded uniquely for that source: Sugar mills burn bagasse (a sugar cane residue), thus bagasse is a fuel type. However, the coding format did not allow for coding bagasse burning as a fuel usage; therefore, bagasse burning was coded as a process source, using process weight rates equal to the burning rate and hand calculating the emissions. Emission factors for bagasse burning were provided by the EQB, based upon incineration of agricultural refuse. Sufficient data on bagasse burning to better quantify emissions are not available.

5.2.3 Coding of Forms

A copy of the point source data form is shown in Appendix C. Each item on that form will be discussed in the following paragraphs to more fully explain the methodology used.

Source Number (Columns 1-3). Each source of emissions was assigned a source number. The computer program requires that source numbers be sequential starting with 1 and be no greater than 999.

Region (Columns 4-6). This identifies the specific AQCR involved. All of Puerto Rico is in AQCR number 244.

SIC (Columns 7-10). Standard industrial classification identifies the type of industry to which this source belongs. The EPA furnished the list of SIC's to be used.

Site (Columns 11-13). This was used primarily to identify multiple sources at a given location.

Process Code (Columns 14-15). The process code was used to identify the type of process or combustion source used based on a list provided by EPA. If a 1-9 value was used in Column 15 it identified a process source.

Description Name (Columns 16-38). These spaces were used to identify the source by the name of the firm and any other descriptor used.

Coordinates (Columns 39-47). The X and Y coordinates relate to the location of the source to the nearest 100 meters in the grid coordinate system used. Each source coded was located, to the best of the information available, on the maps (1:20,000 scale) described

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previously, and the coordinates were read. In many cases these coordinates are only approximate due to the difficulty in locating the point with the information available.

Political Jurisdiction (Columns 48-49). The municipality within which the point source was located determined the political jurisdiction. See Appendix B for the list of political jurisdiction numbers.

Owner (Column 50). The owner of the source was identified as to private (1), local (2), commonwealth (3), federal (4), or a utility (5).

Type (Column 51). The source type was coded as a process (1), fuel combustion (2), or solid waste disposal (3).

Operating Hours (Columns 52-55). The hours of operation specified on the questionnaire were coded here. It is possible that these stated operating hours are the hours that the firm is operating but may not necessarily be the number of hours that material is processed or fuel is consumed.

Stack Parameters (Columns 56-79). Details of the stack height, diameter (at the exit), temperature, velocity of discharges, gas volume, and plume rise were entered here as available and as appropriate.

Process Weight (Columns 4-19). The normal (stated) process weights were converted to process weight rates by dividing the annual processing quantity by the number of operating hours. If a maximum process weight rate was obtainable (or applicable) it was calculated. If unavailable or inapplicable the maximum process weight rate was coded equal to the normal process weight rate.

Maximum Boiler Capacity (Columns 26-30). If a maximum boiler capacity was obtainable for a fuel combustion source it was coded in BTU's per hour. If unobtainable it was coded equal to the normal boiler usage rate.

Fuel Usage (Columns 33-39, 42-48, 51-56, and 59-64). The type of fuel used by a combustion source was determined to be coal, residual oil, distillate oil, or natural gas. The quantity of fuel burned per year was then coded. Natural gas is not used in Puerto Rico; however, if a source burned LPG it was coded as natural gas since no other fuel coding space was available. The emission factor sets utilized for each fuel source were determined from a list provided by the EPA and listed at the beginning of each point source printout.

Heat Content (Columns 59-79). The heat content of each fuel was coded as either the value shown on the source questionnaire (if available), or if no value was given, the following heat values (10^3 BTU/gallon) were used: residual (150) and distillate (140).

Percent Ash-Coal (Columns 4-6). This was not used since coal was not used as a fuel. Coke was used as a fuel in some sources and coded as coal.

Sulfur Content (Columns 7-20). The sulfur content, in percent sulfur by weight, was coded for each fuel. If a sulfur content was specified on the questionnaire it was used. If unspecified, the following percentages were used: kerosene #1 (0.5), diesel #2 (1.0), Navy special #5 (2.5), and Bunker C #6 (2.5).

Control Efficiency (Columns 21-27). If a source had a control device for particulates or SO_2, the control efficiency was determined and coded as a percentage and identified by type in Columns 28-30.

Hand Calculated Emissions (Columns 38-67). The emissions for all process sources (plus bagasse burning) were calculated based on the process type and quantity of material processed. Emission factors were determined from the EPA factors book (McGraw and Duprey 1970). Calculations were made and coded as uncontrolled emissions.

Allowable Emissions (Columns 68-79). These spaces were provided to input the emissions allowed by commonwealth regulations. Since no such regulations currently exist, these spaces were not used.

Comments (Columns 4-79). The D card, normally used only for pertinent comments, was also utilized to record in Columns 4-16 the particulate and sulfur oxide emission limitations recommended by the April 7 Federal Register. Columns 17-79 were then used for comments.

5.3 AREA SOURCES

5.3.1 Obtaining of Data

Area source data were collected for: fuel usage by commercial, institutional, and industrial firms; open burning of waste; solvent evaporation from dry cleaning establishments; seagoing vessels; diesel burning vehicles; gasoline usage for vehicles; LPG use; sugar cane field burning; and aircraft activity at airports.

The APCP had already collected some area source data, primarily for 1969. These data were updated to 1970 where possible. The following paragraphs detail the sources of the area source data and provide a summary of the data.

Fuel Usage. The following data were obtained from the Puerto Rico Office of Economic Indices:

Motor Gasoline		426,528,000 gal
Aviation Fuel		102,910 bbl
Kerosene		990,347 bbl
Solvent		4,975 bbl
Diesel Fuel Oil	- Industrial Consumption	1,684,488 bbl
	- Int. Bunker (vessels)	147,422 bbl
Residual Fuel Oil	- Industrial Consumption	16,591,015 bbl
	- Int. Bunker (vessels)	389,872 bbl

The above fuels represent fuel sales in Puerto Rico in 1970 and thus include fuel used in point sources (except for use at refineries). The Bureau of Mines report which lists fuel consumption by states does not include Puerto Rico nor is information available from the American Petroleum Institute.

Open Burning. Data were supplied by the EQB on refuse disposal by open burning dumps. These figures do not include incineration at apartment houses, or commercial and industrial installations. These latter data are currently being compiled by the EQB but were not available to this study. Data available on open burning show 1869 tons/day burned or 682,185 tons/year.

Solvent Evaporation. Solvent evaporation from dry cleaning establishments was estimated by assuming 13 lbs of clothes cleaned per capita per year in the warm Puerto Rico climate. The EPA emissions factor book suggests 18 lbs/capita in moderate climates and 25 lbs/capita in colder climates. The APCP agreed that 13 lbs/capita was a reasonable assumption. Using the population of 2,801,400 and the solvent evaporation factors of the EPA reference (McGraw and Duprey 1970), the solvent evaporation was estimated to be 2776 tons/year.

Vessels - Diesel. Personnel of the EQB determined the fuel use by vessels while in port based upon: volume of traffic; tonnage of traffic; an average number of ships in port/day (for each port); an average port stay of 1.5 days; a fuel usage of 3696 gallons per motor vessel in port per day and 9,576 gallons per steamer in port per day. The basic vessel data were obtained from the Puerto Rico Ports Authority, Office of Economic Research Report.

Diesel Motor Vehicles. These data were obtained directly from individual petroleum products manufacturers and distributors contacted by the EQB. These data show 28,500,000 gallons of diesel oil sold in Puerto Rico in 1969 to be used for highway transportation. Data for 1970 were not available for this study.

Gasoline Motor Vehicles. Sufficient data on traffic flow volumes were not available. It was determined from the Office of Economic Indices that 426,528,000 gallons of motor vehicle gasoline were consumed in Puerto Rico in 1970. Assuming 12.5 miles per gallon this gives 5,331,600,000 vehicle miles for 1970. This total was split into 3,625,488,000

vehicle miles for urban driving and 1,706,112,000 vehicle-miles for rural driving based upon the ratio of registered vehicles in urban and rural areas.

LPG Usage. The Puerto Rico Office of Economic Indices reported the following sales of LPG in Puerto Rico in 1970:

Butane	837,285 bbl
Propane	1,443,952 bbl
Other LPG	51,670 bbl

These fuel usages were recorded as #19 on the area source fuel list in units of 1000 gallons, noted as "other" on the computer printout; emissions are given in tons/year.

Sugar Cane Field Burning. Data on sugar cane field burning in 1970 were obtained from the administrator of the Sugar Rehabilitation Program. In 1970 it was estimated that 190,000 acres of sugar cane were planted. Approximately 75 percent of the acreage is burned to remove unwanted foliage. This means that 143,000 acres of sugar cane are burned. These data were recorded in acres burned as #22 on the fuel totals sheet noted as "other" on the computer printout sheet; emissions are given in tons/year.

Aircraft Activity at Airports. Aircraft activity at each airport in Puerto Rico was determined by EQB personnel based upon data supplied by the Puerto Rico Ports Authority. Table 3 shows the number of landing-takeoff cycles (flights) or LTO's determined for each aircraft type. The emissions from this aircraft activity were hand

Table 3. Landing-Takeoff Cycle for All Aircraft Types

Airport	Type Aircraft		Landing-Takeoffs (LTO's)
SAN JUAN INTERNATIONAL	Jet:	2 Engine	4,904
		3 Engine	4,491
		4 Engine	16,551
	Turboprop:	2 Engine	5,411
		4 Engine	84
	Piston:	2 Engine	12,973
		4 Engine	26,427
Subtotal			70,841
PONCE AIRPORT	Turboprop:	2 Engine	1,486
	Piston:	2 Engine	152
		4 Engine	5,978
Subtotal			7,616
MAYAGUEZ AIRPORT	Turboprop:	2 Engine	1,135
	Piston:	2 Engine	121
		4 Engine	3,895
Subtotal			5,151
Total			83,608

calculated and entered on the area source sheets in Column 1 emissions for the municipalities of Carolina, Ponce, and Mayaguez, respectively.

5.3.2 Adjustment of Fuel Totals

The fuel totals shown in Section 5.3.1 include fuel consumed by point sources that are considered in the point source inventory. Thus this fuel must be subtracted from the commonwealth total before the input for the area source data deck is determined. The fuel of each type consumed by point source is available as an output of the point source emission inventory.

The point source results show that 654,914,000 gallons of residual and 250,844,000 gallons of distillate oil were consumed by the point sources. However, part of the point source total was consumed by refineries, which used fuel not already included in the commonwealth totals. Residual fuel for industrial point sources to be subtracted from Puerto Rico totals is 643,644,000 gallons, leaving 53,179,000 gallons for allocation to area sources. Commercial and institutional residual totals remain unchanged at zero (0) gallons. Industrial point source distillate oil to be subtracted is 42,845,000 gallons, leaving 27,903,000 gallons for area source allocation. Commercial and institutional distillate oil usage to be subtracted is 1,864,000 gallons, leaving 39,731,000 gallons to be allocated to area sources.

LPG usage by industrial sources was 14,335 x 10^6 cubic feet. This usage was almost all by petroleum refineries, therefore, this point source LPG usage is not subtracted from the previously given island-wide LPG use. Thus 97,982,000 gallons of LPG is allocated to area sources.

5.3.3 Emission Factors

The emission factors used for area sources were provided by EPA in the area source format for all but LPG, sugar cane field burning, and aircraft emissions.

The LPG emission factors used (LPG in the coding is fuel group 19) are a weighted average between butane and propane factors found in McGraw and Dupreys' Compilation of Air Pollutant Emission Factors, 1970 weighted by the quantity of each. Thus the LPG emission factors used are: particulates, 6.3 pounds/10^3 gallons; sulfur oxides, zero (0);

carbon monoxide, 6.6 pounds/10^3 gallons; hydrocarbons, 2.6 pounds/10^3 gallons; and nitrous oxides, 35.0 pounds/10^3 gallons.

Sugar cane field burning factors were obtained from McGraw and Duprey (1970) and are: 0.113 tons/acre for particulates; zero (0) for sulfur oxides; 0.75 tons/acre for carbon monoxide; 0.15 tons/acre for hydrocarbons; and 0.015 tons/acre for nitrous oxides.

Aircraft emission factors were not input to the data as these emissions were hand calculated. The factors used are found in McGraw and Duprey (1970).

5.3.4 Apportioning Factors

The apportioning factors for the consumables considered for area source allocation are shown for each municipality and grid square in Table 6-1 of the computer listing (not included in this report) for each area source data run. The following paragraphs will specify the basis for each apportioning factor set but will not repeat the factors available in the computer printout. Factors were basically determined using the methods of Bierbaum and Gedgaudas (undated).

Factors 1-3: Residential Fuel. No factors were used since residential fuel is not used.

Factors 4-7: Commercial and Institutional Fuel. Bierbaum and Gedgaudas specify that the ratio of retail and wholesale employees should be used in determining the allocation factors for this group. The usual source of data for the factors is in the yearly census of business for retail trade and for wholesale trade for a given state, published by

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the U.S. Department of Commerce. These publications were not available for Puerto Rico. However, the Office of Labor Statistics of the Puerto Rico Department of Labor publishes an annual listing of manufacturing establishments in Puerto Rico. The October 1969 issue (Estado Libre Asociado de Puerto Rico) was the latest issue available. The number of commercial businesses in each municipality was determined from this reference and used as the apportioning factors for Factors 4-7.

Factors 8-11: Non-Point Source Industrial Fuel. Again Bierbaum and Gedgaudas recommend a Bureau of the Census document on a census of manufacturers to get the number of manufacturing employees. This was not available for Puerto Rico. The annual listing of the Puerto Rico Department of Labor was used to determine the number of industrial firms in each municipality. The number of industrial firms was used as the apportioning factor.

Factor 13: Open Burning. Open burning totals were established on a per capita waste accumulation basis. Population is used as the apportioning factor for each municipality to allocate open burning.

Factor 15: Solvent Evaporation. As in Factor 13, population is the apportioning factor for solvent evaporation.

Factor 16: Vessels. The quantity of fuel used for this source was based on the number of ships in port. Thus the apportioning factor used is the number of ships in port in a given municipality.

Factor 18: Diesel Motor Vehicles. The apportioning factor is the number of diesel burning vehicles registered in a given municipality.

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Factor 19: LPG Usage. The LPG usage was primarily by commercial and institutional users. Thus the apportioning factors for LPG were the numbers of businesses in a municipality.

Factors 20-21: Gasoline Motor Vehicles. The number of automobiles, trucks, pickups, government vehicles, motorcycles, and busses registered in each municipality was obtained for 1970 from the Department of Public Works, Bureau of Motor Vehicles. First a determination was made for a given municipality to see if it was all urban (thus 25 mph traffic) or all rural (thus all 45 mph traffic). This was based on the percent of urban or rural area in the municipality. For those municipalities having a significant mixture of urban and rural (mostly rural), the vehicle registration was used. In these cases automobiles were considered as 45 mph traffic with the remainder of the vehicles as 25 mph traffic. Thus the apportioning factors were the numbers of vehicles in each speed category registered in each municipality.

Factor 22: Sugar Cane Field Burning. The number of acres of sugar cane burned in each municipality was estimated and used as the apportioning factor.

Section 6.0

REFERENCES

Bierbaum, Philip J. and Marius J. Gedgaudas. Undated. Air Pollutant Emission Inventory Techniques. HEW-PHS.

Estado Libre Asociado de Puerto Rico, Departamento del Trabajo, Negociado de Estadisticas del Trabajo. 1969. Establecimientos Manufactureros en Puerto Rico. Octubre de 1969.

McGraw, M. J. and R. L. Duprey. 1971. Compilation of Air Pollutant Emission Factors. Preliminary Document. Environmental Protection Agency. April 1971.

Appendix A

EMISSIONS INVENTORY SUMMARY

The computer printout for the point and area source emission inventory give detailed results for each source and each municipality. Table A-1 is provided to present a detailed summary of emissions in a form similar to that specified in Appendix D of the August 14, 1971 Federal Register. This form is as similar to the suggested Appendix D format as can be made with the existing computer printout format. It differs from the suggested format in that the suggested categories of Commercial-Institutional Fuel Combustion and Industrial Fuel Combustion are grouped into one category, Commercial-Institutional-Industrial Fuel Combustion. The other major difference is that process losses in Table A-1 can not be broken out into the categories suggested by Appendix D due to the nature of the computer printout.

Space for additional entries under allowed emissions is provided on Table A-1 to facilitate the addition of control strategy data as these data are developed for the implementation plan in another task.

Puerto Rico is suggested as Priority III for CO, HC, and NO_x, thus control strategies will not be developed. Control strategies will be developed for particulates and sulfur oxides.

Table A-1. Emissions Inventory Summary, Tons/Year*

Source Category	Pollutant						
	Particulates		Sulfur Oxides		Carbon Monoxide	Hydrocarbons	Nitrogen Oxide
	(1) Existing	(2) Allowed	(1) Existing	(2) Allowed	(1) Existing	(1) Existing	(1) Existing
I. Fuel Combustion - Stationary Sources							
A. Residential Fuel: (Total)	0		0		0	0	0
B. Commercial - Institutional - Industrial							
1. Coal - (Total)	0		0		0	0	0
2. Coke - Point Sources	0		0		21	5	1
3. Distillate Oil							
a. Area Sources	507		4,870		7	102	2,029
b. Point Sources	1,698		16,926		23	340	6,791
4. Residual Oil							
a. Area Sources	612		10,569		5	80	1,595
b. Point Sources	2,120		25,740		19	279	5,586
5. Natural Gas - (Total)	0		0		0	0	0
6. Process Gas - Point Sources	108		4		3	287	2,795
7. Wood - (Total)	0		0		0	0	0
8. LPG - Area Sources	309		0		323	127	1,715
9. Total	5,354		58,109		401	1,220	20,512
C. Steam Electric Power Plant							
1. Coal	0		0		0	0	0
2. Distillate Oil	98		266		0	61	1,284
3. Residual Oil	1,875		74,523		9	1,172	24,607
4. Natural Gas	0		0		0	0	0
5. Total	1,973		74,789		9	1,233	25,891
D. Total Fuel Combustion	7,327		132,898		410	2,453	46,403

(Continued)

* Puerto Rico Air Quality Control Region 244, Data Representative of Calendar Year 1970.

Notes: (1) Existing emissions based on inventory for 1970.

(2) Allowed emissions based on particulate and sulfur oxide control strategies selected for the implementation plan.

Table A-1. Emissions Inventory Summary, Tons/Year (Concluded)

Source Category	Pollutant						
	Particulates		Sulfur Oxides		Carbon Monoxide	Hydrocarbons	Nitrogen Oxide
	(1) Existing	(2) Allowed	(1) Existing	(2) Allowed	(1) Existing	(1) Existing	(1) Existing
II. Process Losses							
A. Area Sources	0		0		0	0	0
B. Point Sources	79,387		2,594		60,097	12,229	6,599
C. Total Process Losses	79,387		2,594		60,097	12,229	6,599
III. Solid Waste Disposal							
A. Incineration (Total)	0		0		0	0	0
B. Open Burning							
1. Onsite	0		0		0	0	0
2. Dumps - Area Source	5,457		341		28,993	10,233	2,047
C. Total Solid Waste Disposal	5,457		341		28,993	10,233	2,047
IV. Transportation - Area Sources							
A. Motor Vehicles	1,759		1,066		491,466	83,983	55,598
1. Gasoline	356		641		4,631	926	4,845
2. Diesel	0		0		0	0	0
B. Off-Highway Fuel Usage	433		260		14,009	2,689	904
C. Aircraft	0		0		0	0	0
D. Railroads	468		6,733		1,216	935	1,365
E. Vessels	0		0		0	0	0
F. Gasoline Handling - Evaporative Losses							
G. Total Transportation	3,016		8,700		511,322	88,533	62,712
V. Miscellaneous - Area Sources							
A. Sugar Cane Field Burning	8		0		54	11	1
B. Dry Cleaners Evaporation	0		0		0	2,776	0
C. Total Miscellaneous	8		0		54	2,787	1
VI. Region Grand Totals							
A. Area Sources	9,909		24,480		540,704	101,862	70,099
B. Point Sources	85,286		120,053		60,172	14,373	47,663
C. Total for Region	95,195		144,533		600,876	116,235	117,762

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Appendix B

PUERTO RICO POLITICAL JURISDICTIONS

Puerto Rico is subdivided into municipalities. For coding purposes, a political jurisdiction number has been assigned to each municipality on the main island. This enables a summary of emissions by municipality.

Previous work in Puerto Rico considered five health regions. Although this has no necessary relationship to the AQCR, it was decided to number the municipalities alphabetically by health regions. This numbering is shown in Table B-1. A further island-wide alphabetical listing is shown for convenience in Table B-2.

Table B-1. Listing of Municipalities by Health Region With Corresponding Political Jurisdiction Number

Municipality	Political Jurisdiction
Northeast Region	
Aguas Buenas	1
Barranquitas	2
Bayamón	3
Carolina	4
Cataño	5
Cidra	6
Comerio	7
Corozal	8
Dorado	9
Guaynabo	10
Naranjito	11
Rio Piedras	12 *
San Juan	13
Toa Alta	14
Toa Baja	15
Trujillo Alto	16
South Region	
Adjuntas	17
Albonito	18
Arroyo	19
Coamo	20
Guanica	21
Guayama	22
Guayanilla	23
Jayuya	24
Juana Diaz	25
Orocovis	26
Patillas	27
Peñuelas	28
Ponce	29
Salinas	30
Santa Isabel	31
Villalba	32
Yauco	33
West Region	
Aguada	34
Aguadilla	35
Añasco	36
Cabo Rajo	37
Hormigueros	38
West Region (cont.)	
Isabela	39
Lajas	40
Las Marias	41
Maricao	42
Mayaguez	43
Moca	44
Rincón	45
Sabana Grande	46
San German	47
San Sebastian	48
North Region	
Arecibo	49
Barceloneta	50
Camuy	51
Ciales	52
Hatillo	53
Lares	54
Manati	55
Morovis	56
Quebradillas	57
Utuado	58
Vega Alta	59
Vega Baja	60
East Region	
Caguas	61
Cayey	62
Ceiba	63
Fajardo	64
Gurabo	65
Humacao	66
Juncos	67
Las Piedras	68
Loiza	69
Luquillo	70
Maunabo	71
Naguabo	72
Rio Grande	73
San Lorenzo	74
Yabucoa	75

* No longer used as Rio Piedras and San Juan Municipalities have been merged into San Juan (#13).

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Table B-2. Alphabetical Listing of Municipalities With Assigned Political Jurisdiction Number

Municipality	Political Jurisdiction	Municipality	Political Jurisdiction
Adjuntas	17	Lares	54
Aguada	34	Las Marias	41
Aguadilla	35	Las Piedras	68
Aguas Buenas	1	Loiza	69
Albonito	18	Luquillo	70
Añasco	36	Manati	55
Arecibo	49	Maricao	42
Arroyo	19	Maunabo	71
Barceloneta	50	Mayaguez	43
Barranquitas	2	Moca	44
Bayamón	3	Morovis	56
Cabo Rojo	37	Naguabo	72
Caguas	61	Naranjito	11
Camuy	51	Orocovis	26
Carolina	4	Patillas	27
Cataño	5	Peñuelas	28
Cayey	62	Ponce	29
Ceiba	63	Quebradillas	57
Ciales	52	Rincón	45
Cidra	6	Rio Grande	73
Coamo	20	Rio Piedras	12*
Comerio	7	Sabana Grande	46
Corozal	8	Salinas	30
Dorado	9	San German	47
Fajardo	64	Santa Isabel	31
Guayama	22	San Juan	13
Guayanilla	23	San Lorenzo	74
Guaynabo	10	San Sebastian	48
Guanica	21	Toa Alta	14
Gurabo	65	Toa Baja	15
Hatillo	53	Trujillo Alto	16
Hormigueros	38	Utuado	58
Humacao	66	Vega Alta	59
Isabela	39	Vega Baja	60
Jayuya	24	Villalba	32
Juana Diaz	25	Yabucoa	75
Juncos	67	Yauco	33
Lajas	40		

* No longer used as a separate municipality.

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A

POINT SOURCE DATA FORM

SOURCE NUMBER	REGION	SIC	SITE	PROCESS CODE	DESCRIPTIVE NAME (a)	COORDINATES KM X	COORDINATES KM Y	POLITICAL JURISDICTION	OWNER (b)	TYPE (c)

SOURCE NUMBER	MAXIMUM PROCESS WEIGHT RATE (lb/hr)	NORMAL PROCESS WEIGHT RATE (lb/hr)	COMMENTS (a)	MAXIMUM BOILER CAPACITY (10^6 BTU/hr)	(d) E F	COAL (tons/year)	(d) E F	RESIDUAL OIL (10^3 Gal/year)	(d) E F	DI

SOURCE NUMBER	% ASH COAL	SULFUR CONTENT COAL	SULFUR CONTENT RESID.	SULFUR CONTENT DIST.	SULFUR CONTENT NAT. GAS	CONTROL EFFICIENCY PART	CONTROL EFFICIENCY SO_2	DEVICE INDENT	COMMENTS (a)	HAND CALCUL (tons) PART.	HAND CALCUL (tons) SO_2

SOURCE NUMBER	COMMENTS (a)

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 S

(a) Letters and numbers may be put in these columns

(b) Owner → Private = 1; Local = 2; State = 3; Federal = 4; Utilities = 5.

(c) Type → Process = 1; Fuel Combustion = 2; Solid Waste Disposal = 3.

(d) EF → refers to emission factor set number associated with emission factors on emission factor sheet.

(e) Decimal points are implied and are signified by a ▼ between columns.

B

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POINT SOURCE DATA FORM

(a)	COORDINATES KM X	COORDINATES KM Y	POLITICAL JURSDICTION	OWNER (b)	TYPE (c)	OPERATING (hours/year)	STACK PARAMETERS HEIGHT (ft.)	STACK PARAMETERS DIA. (ft.)	STACK PARAMETERS TEMP. (°F)	STACK PARAMETERS VELOCITY (ft/sec)	MAXIMUM GAS VOLUME 10^2 (ACFM)	PLUME RISE (ft^2/sec)	
													A

(d) E F	COAL (tons/year)	(d) E F	RESIDUAL OIL (10^3 Gal/year)	(d) E F	DISTILLATE OIL (10^3 Gal/ year)	(d) E F	NATURAL GAS (10^6 CF/year)	HEAT CONTENT COAL 10^6 (BTU/ ton)	HEAT CONTENT RESIDUAL OIL (10^3 BTU/ Gal.)	HEAT CONTENT DIST. OIL (10^3 BTU/ Gal.)	HEAT CONTENT NATURAL GAS (BTU/ CF)	
												B

COMMENTS (a)	HAND CALCULATED EMISSIONS (tons/year) PART.	SO_2	CO	HC	NO_2	ALLOWABLE EMISSIONS (tons/year) PART	SO_2	
								C

	D

31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80

factor